



HUBBLE SPACE TELESCOPE PROJECT

HST SM4 Battery Capacity

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SM-4 Battery Shelf Life Study

BMA Capacity Test Vortex Cart



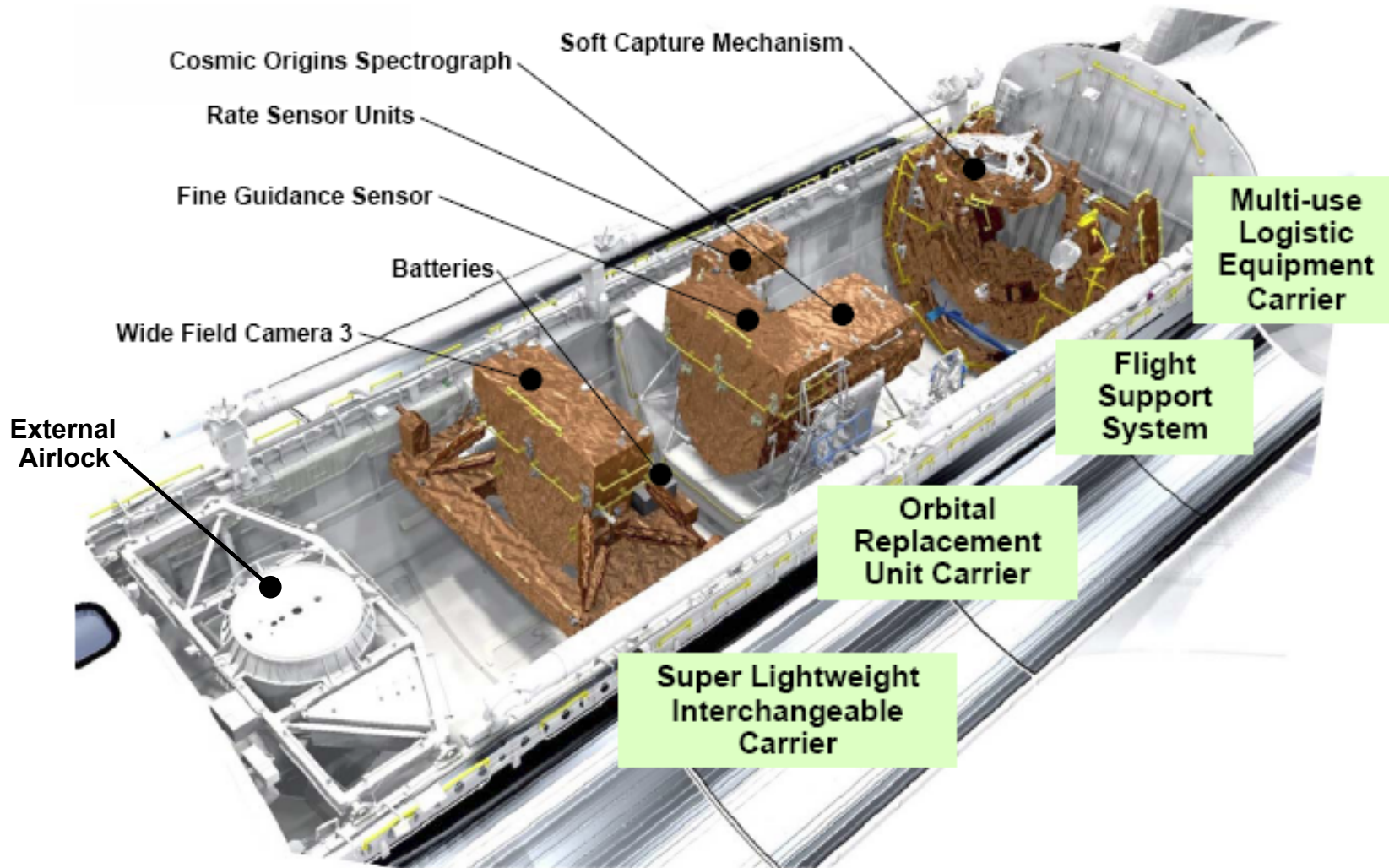
BMA 0°C Capacity Test Using Vortex Cooling Carts



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SM-4 Battery Shelf Life Study

Shuttle Pay Load Locations





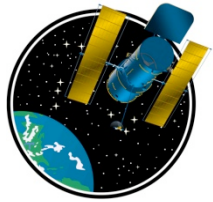
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SM-4 Battery Shelf Life Study

BMA Capacity Test Super Lightweight Instrument Carrier (SLIC)



SLIC Mockup Showing One Battery Module



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SM-4 Battery Shelf Life Study

HST Capture by Shuttle

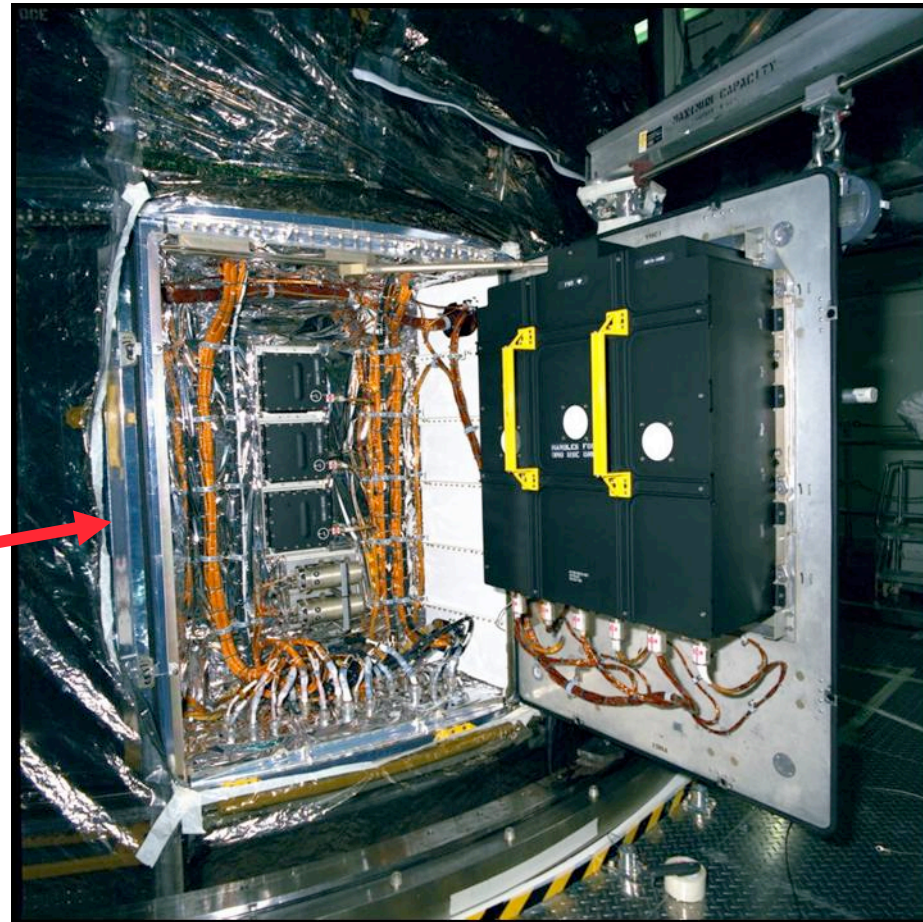
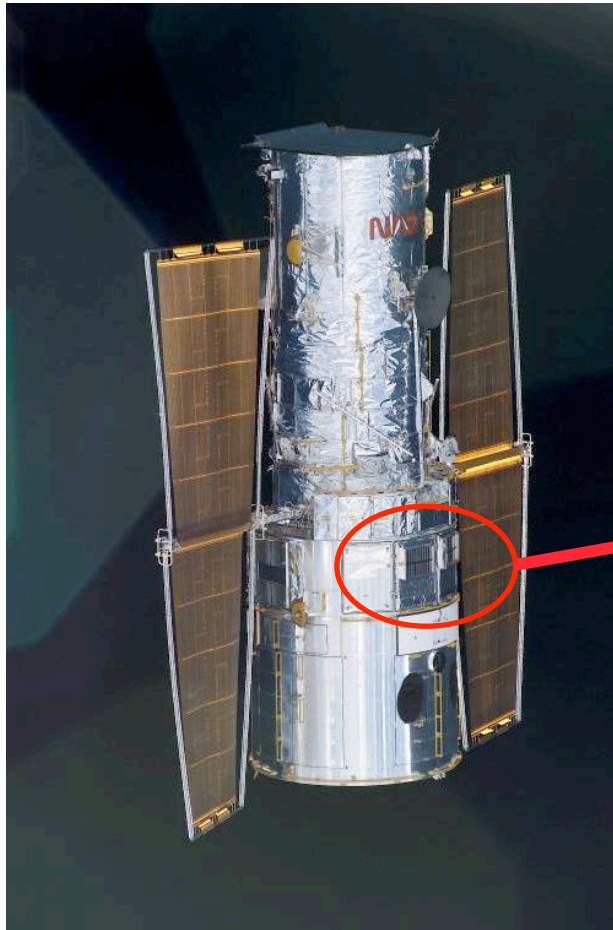




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SM-4 Battery Shelf Life Study

BMA Installed onto HST



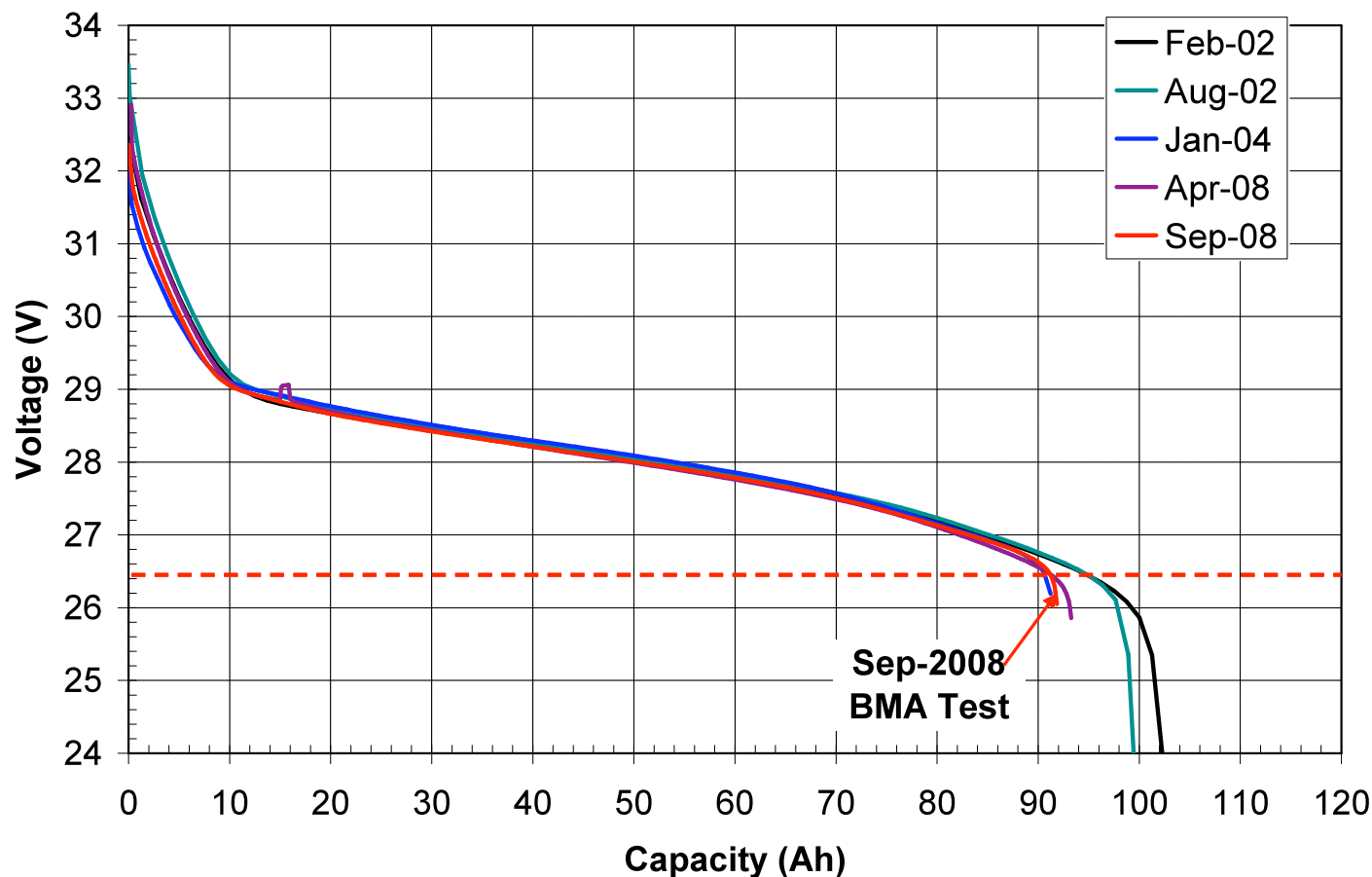
Servicing Bays for Batteries



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SM-4 Battery Shelf Life Study

BMA Capacity Trend BMA 1033, Battery S/N 1165



**2008 BMA Capacity Test Verifies
Capacity Requirement >86 Ah to 26.5V**

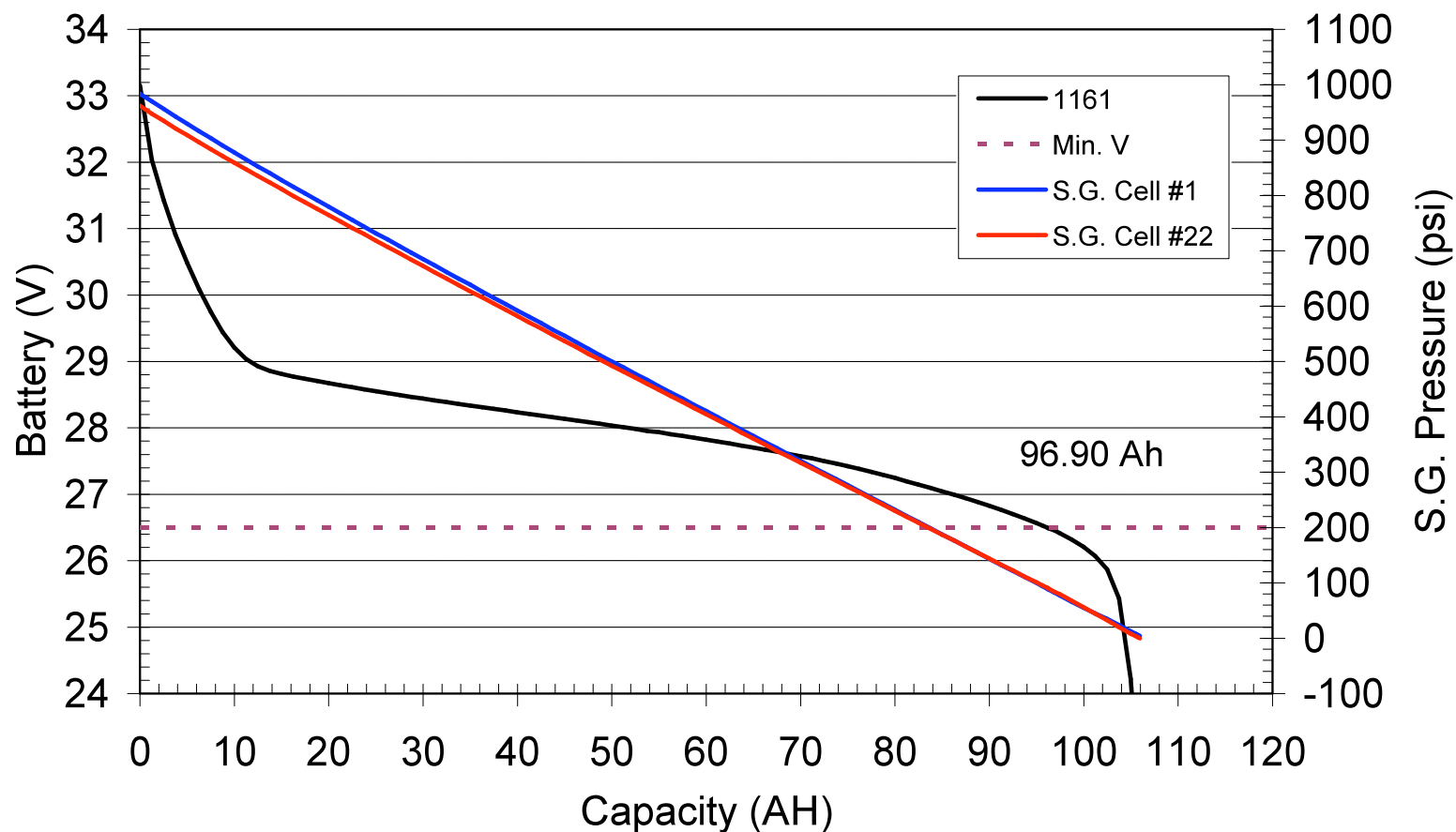




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SM-4 Battery Shelf Life Study

February-2002 Battery ATP 0 °C Capacity Test
Battery S/N 1161



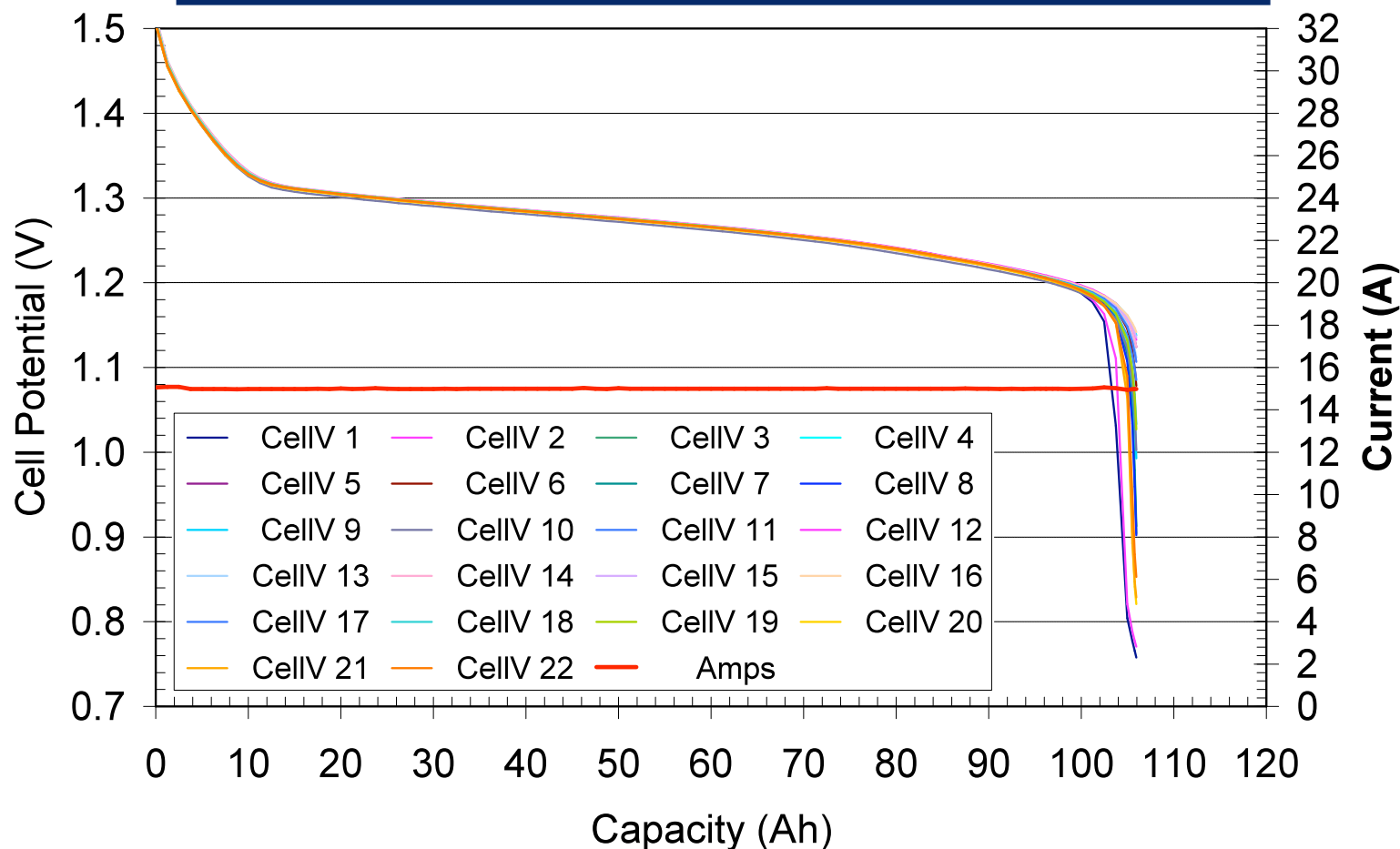
Full Range Pressure Telemetry – Not Truncated at ~200 psi



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SM-4 Battery Shelf Life Study

February-2002 Battery ATP 0 °C Capacity Test
Battery S/N 1161



No Sign of 2nd Plateau Capacity – Cells Well Matched

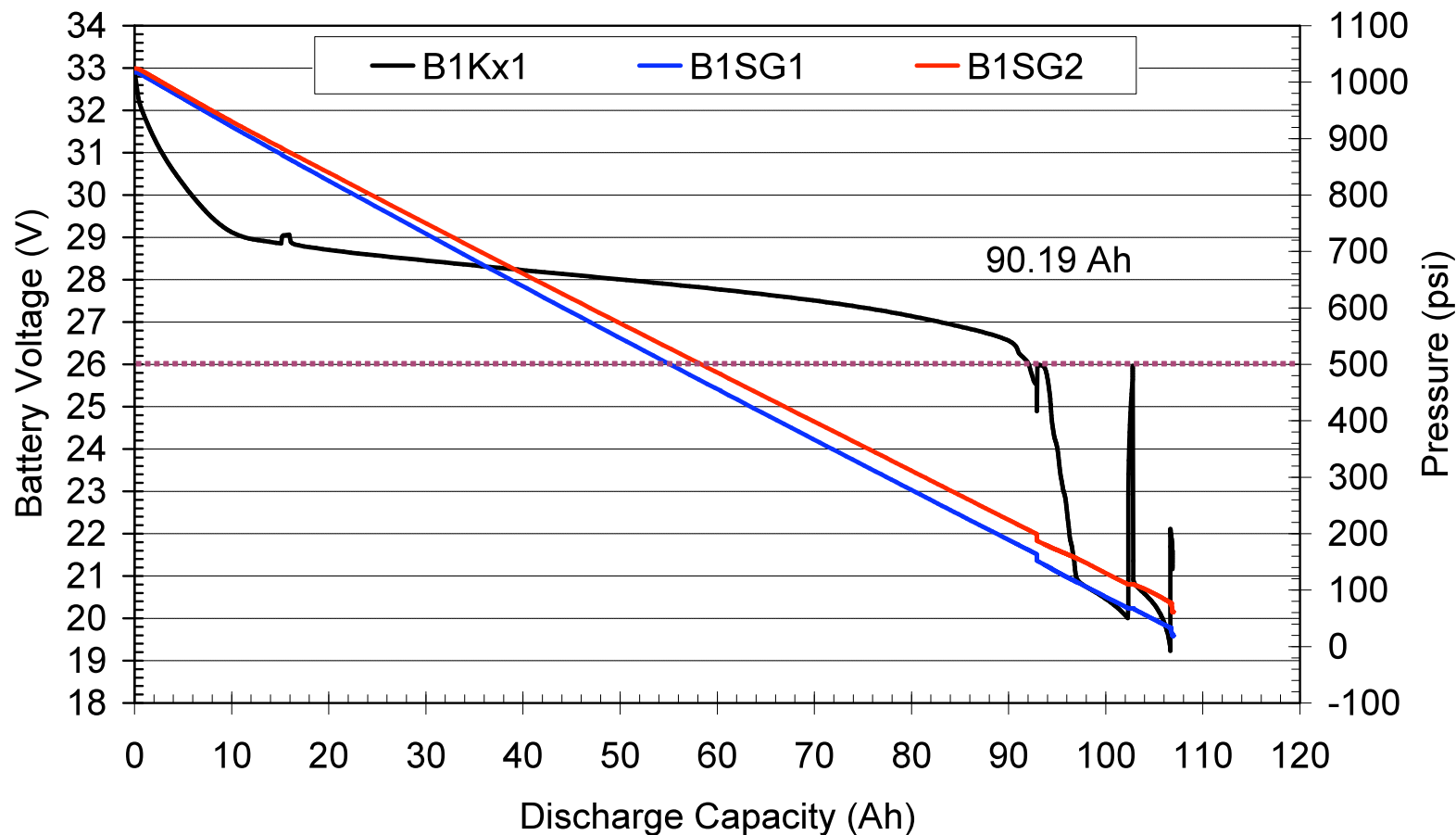




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SM-4 Battery Shelf Life Study

March 2008 Battery ATP 0 °C Capacity Test
Battery S/N 1161



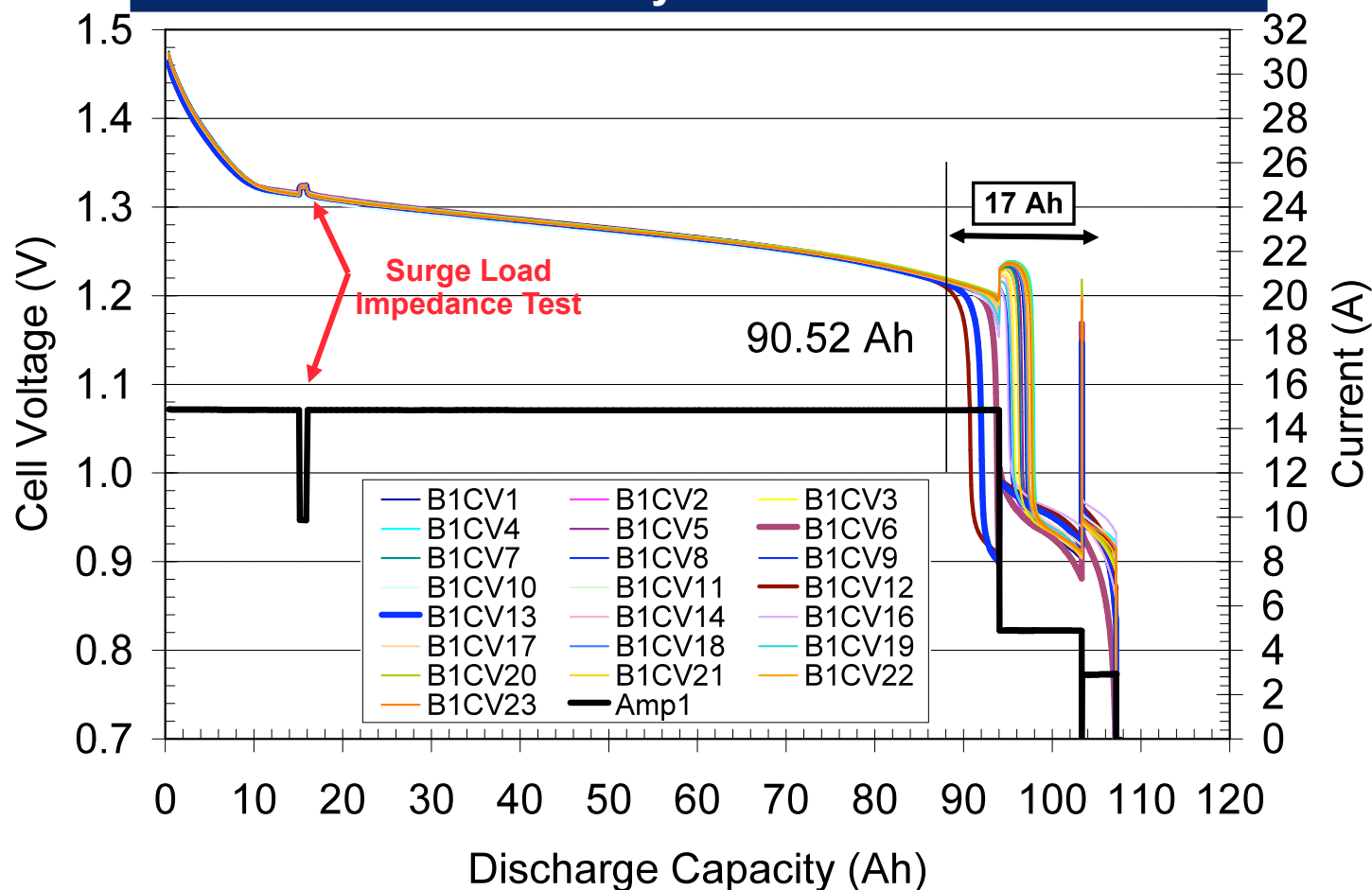
Note 200 psi Remains When Battery Reaches 26.5V



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SM-4 Battery Shelf Life Study

March-2008 BMA 0 °C Capacity Test Battery S/N 1161



Significant 2nd Plateau Capacity Observed

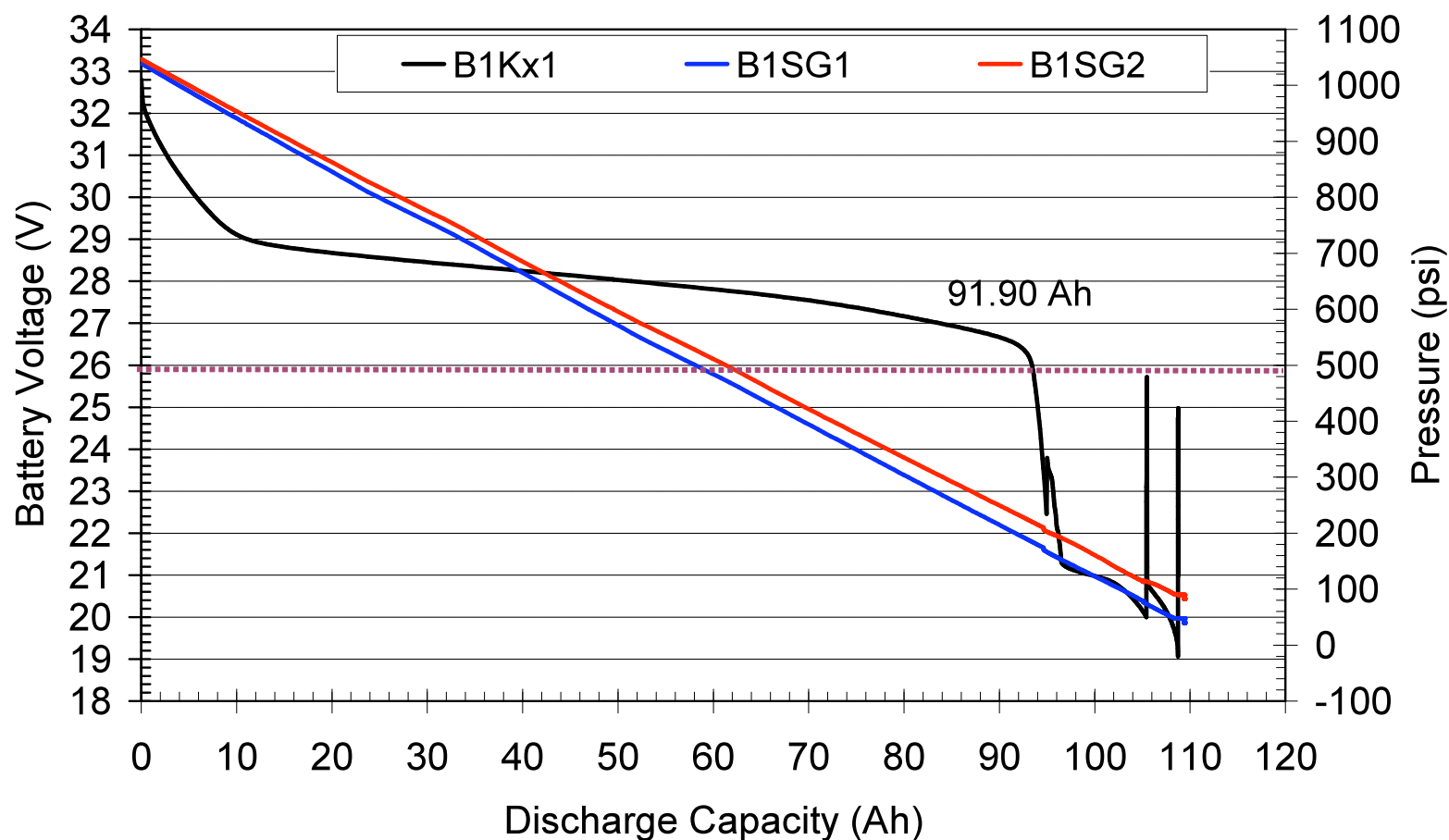




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SM-4 Battery Shelf Life Study

September 2008 Battery ATP 0 °C Capacity Test
Battery S/N 1161



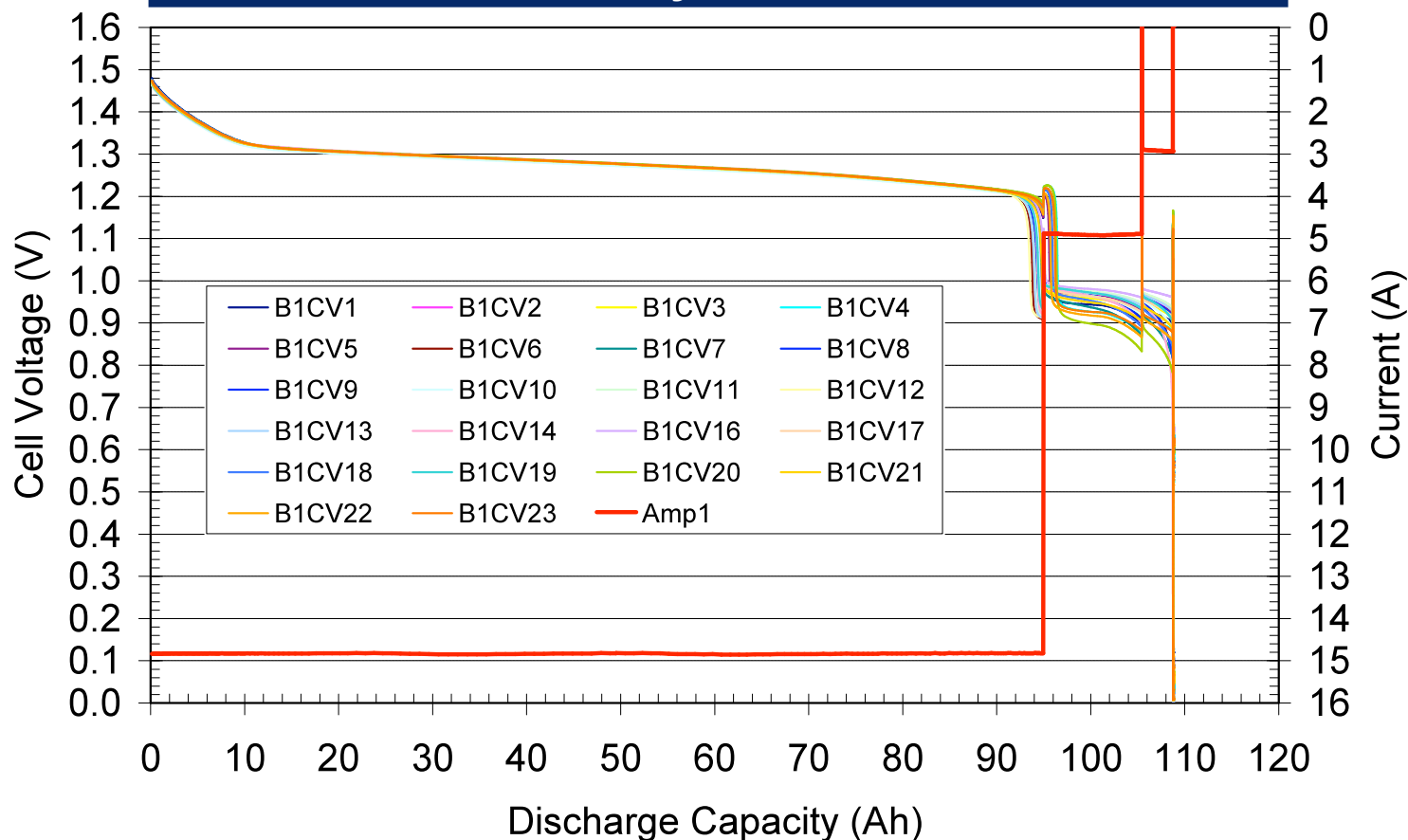
91.90 Ah Observed Capacity - Meets 86 Ah Requirement



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SM-4 Battery Shelf Life Study

September-2008 BMA 0 °C Capacity Test
Battery S/N 1161



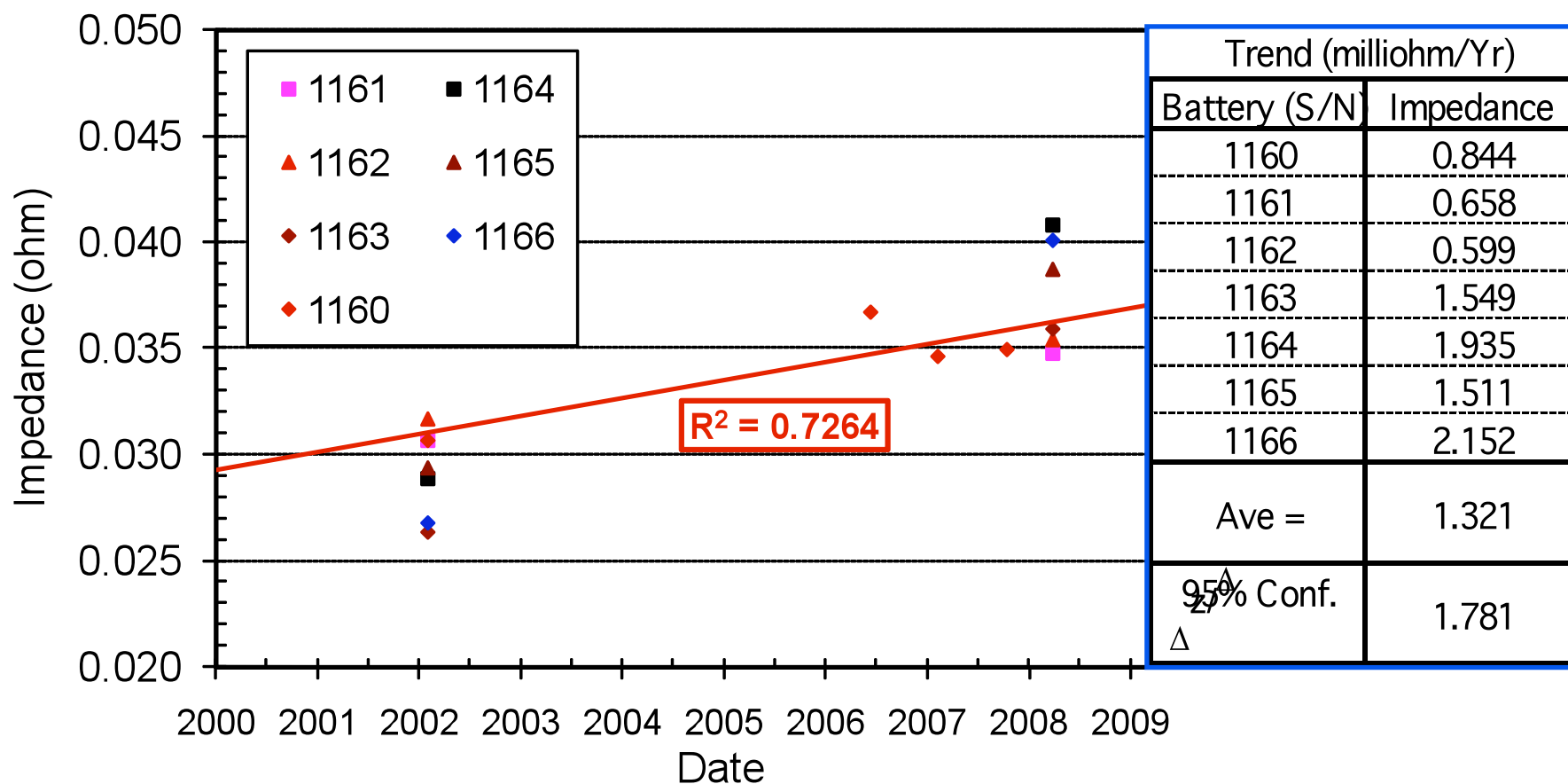
Significant 2nd Plateau Capacity Observed



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SM-4 Battery Shelf Life Study

Surge Load Impedance Trend



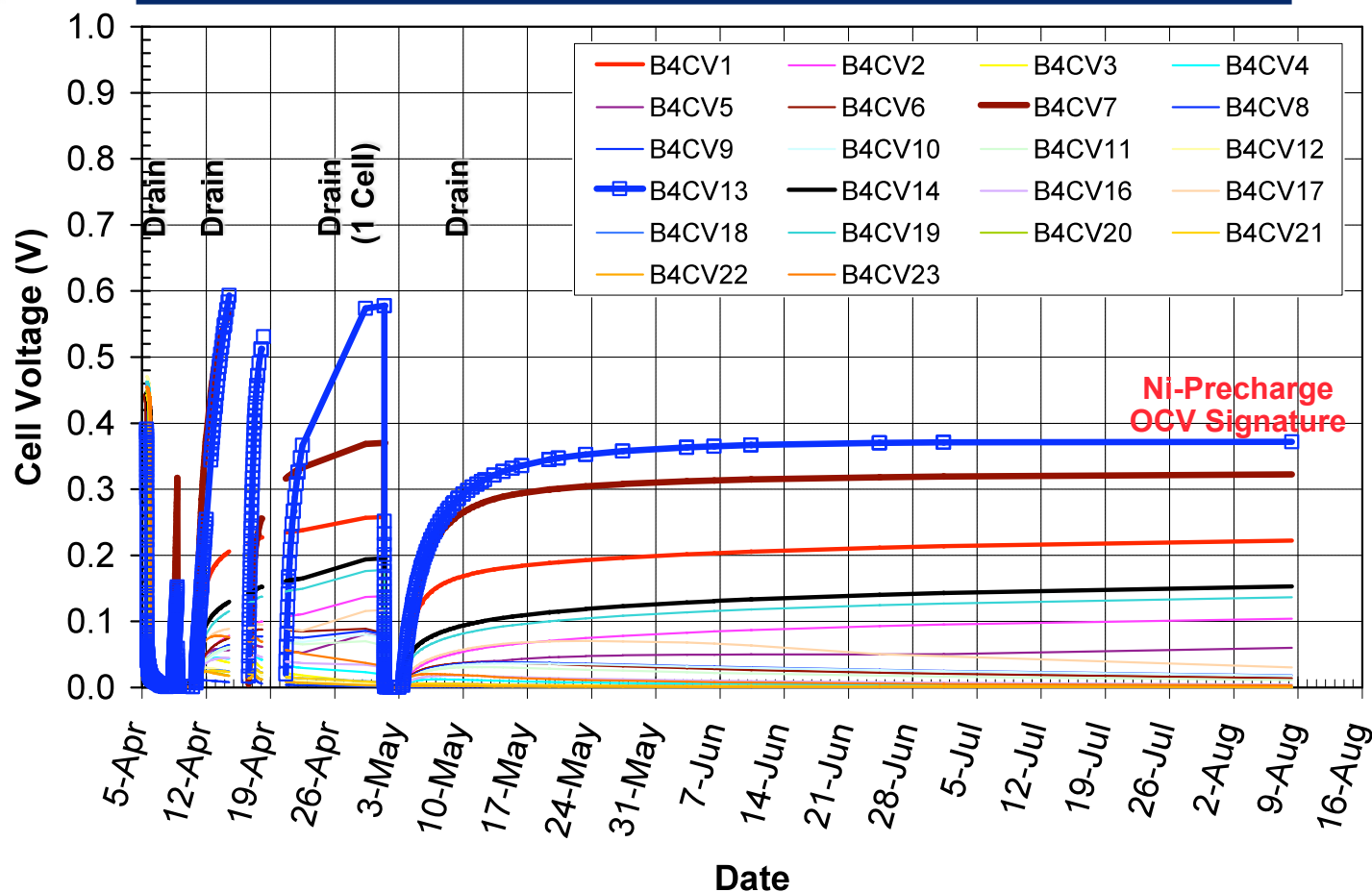
Impedance From Surge Load Test Increases With Age
Lot 11 Cells Increasing Faster Than Lot 10



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SM-4 Battery Shelf Life Study

BMA 1033 – Battery 1166 OCV Drain



**Cell Voltages Below 0.5V for Cold Storage
All Ni-Precharge**

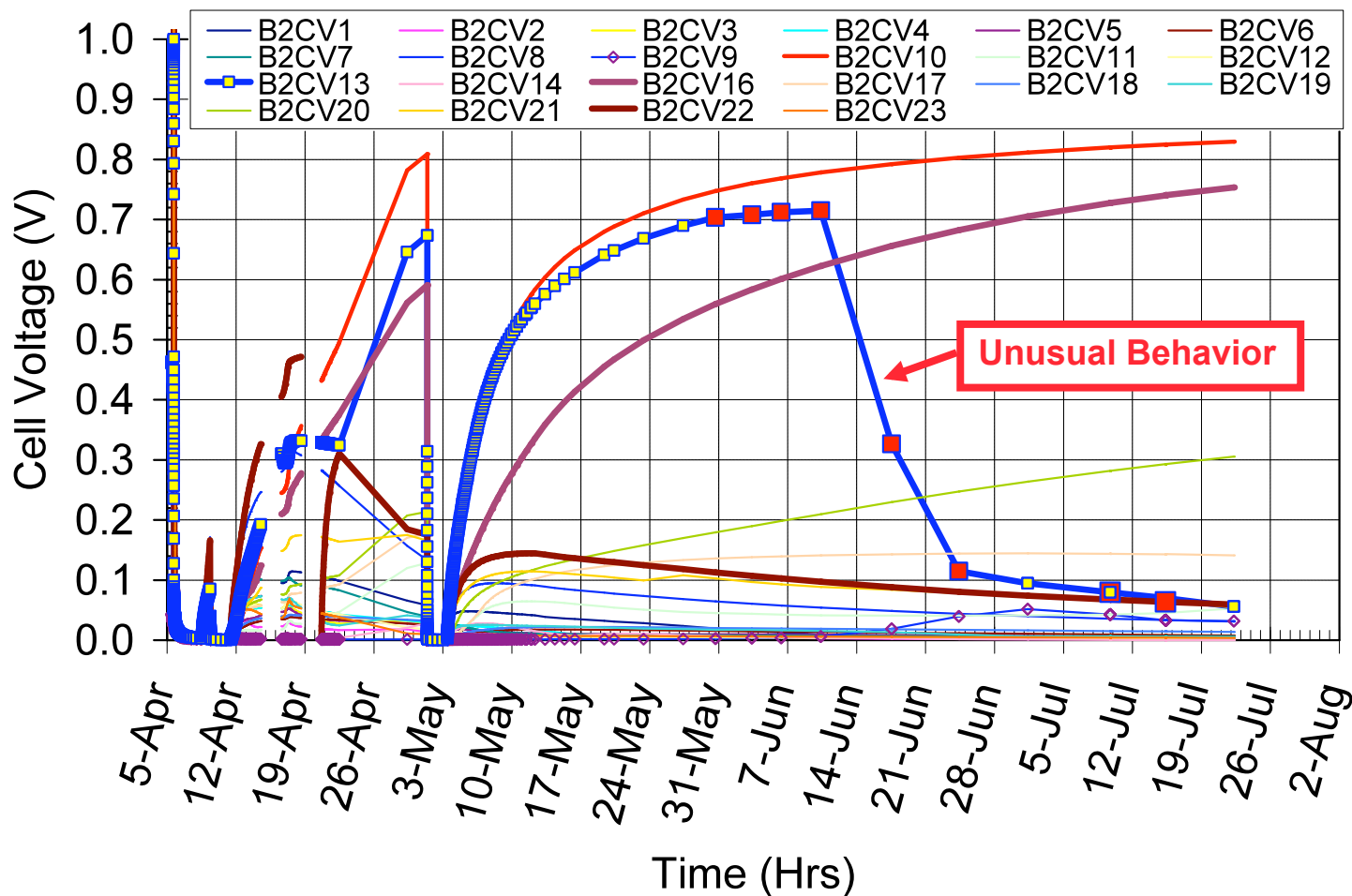




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SM-4 Battery Shelf Life Study

BMA 1032 – Battery 1162 OCV Drain



OCV Signatures Suggests Mixture of Ni Species

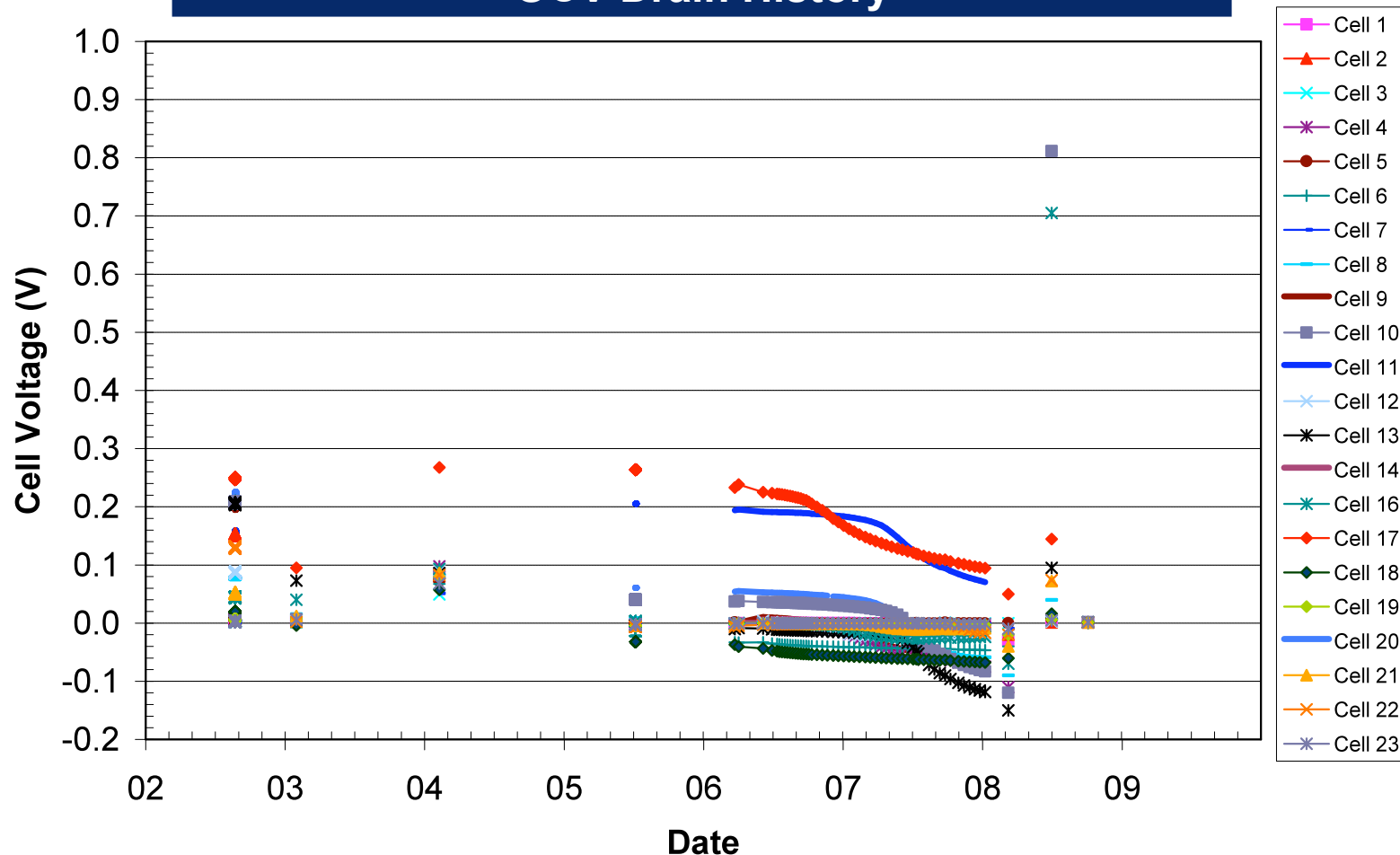




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SM-4 Battery Shelf Life Study

BMA 1032 – Battery 1162 OCV Drain History



OCV Signatures Suggests Mixture of Ni Species

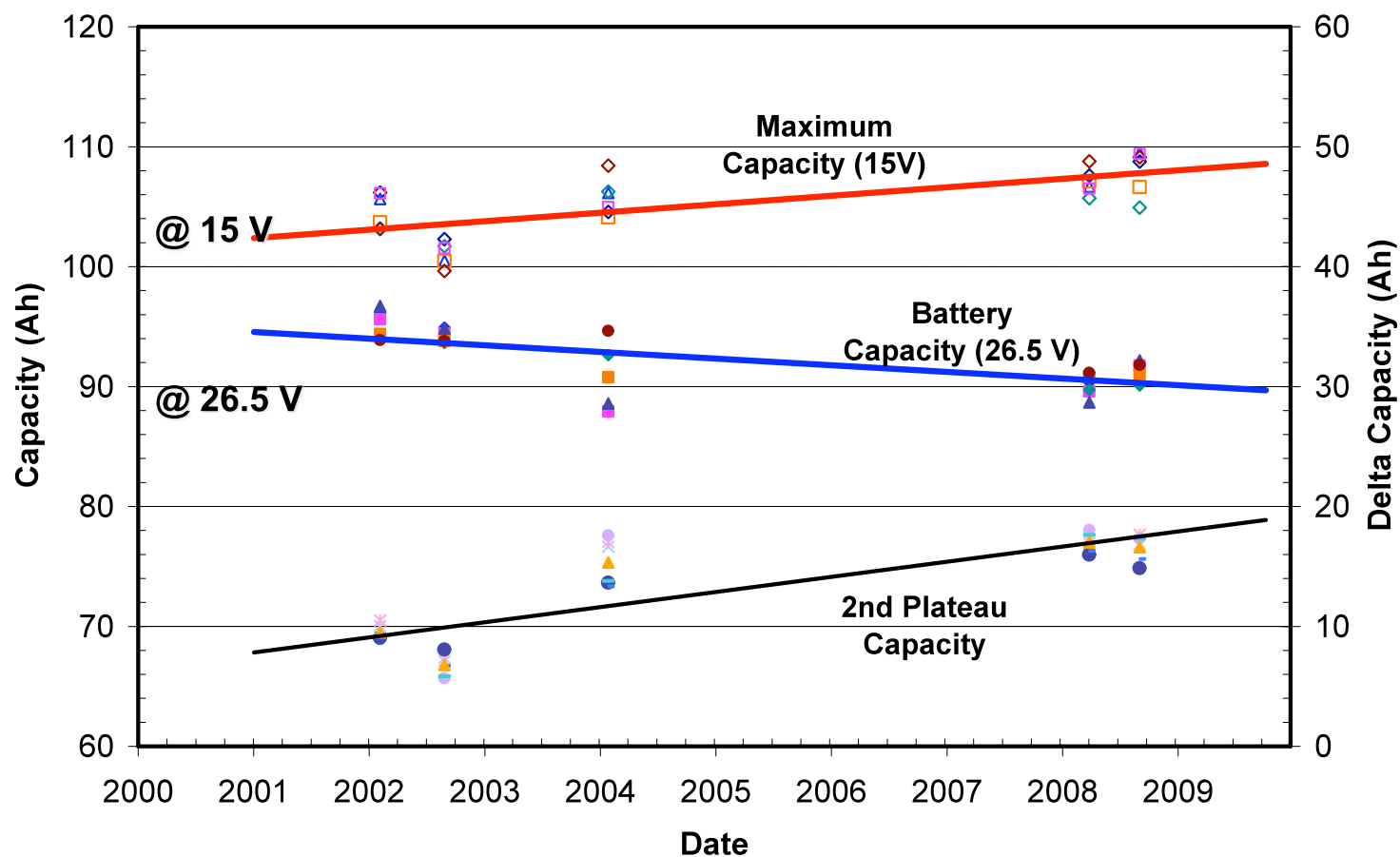




HUBBLE SPACE TELESCOPE PROJECT

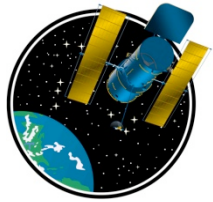
SM-4 Battery Shelf Life Study

HST Flight Battery 0 °C Capacity Trending



Total Ah Increase with Age (Ni-Precharge Loss) - Usable Ah Decreases with 2nd Plateau Ah Increases





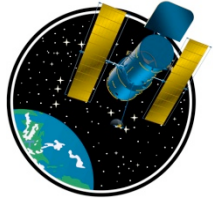
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SM-4 Battery Shelf Life Study

Summary of HST Battery Flight Readiness

- Flight Battery Storage History
 - 4 Year Dry Storage
 - 8 Year Wet Storage
- Flight Battery Test History
 - Battery ATP (5 Cycles) (2002)
 - Module ATP
 - Eagle Picher – Module ATP (2002)
 - GSFC – Acceptance ATP (2004)
 - GSFC – Capacity Check ATP (3-2008)
 - GSFC – Preship Capacity Test (9-2008)
 - KSC – Wakeup Capacity Test (9-2008)
 - Capacity and Impedance Growth Observed
- Preship Capacity Test
 - 92 Ah at 0 C
 - 86 Ah Requirement

Flight Batteries are “Good to Go”



HUBBLE SPACE TELESCOPE PROJECT

SM-4 Battery Shelf Life Study

Acknowledgement

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